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**ATTN: Document Control Desk**

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YUCCA MOUNTAIN - REQUEST FOR ADDITIONAL INFORMATION - VOLUME 2,  
CHAPTER 2.1.1.2, SET 1 (DEPARTMENT OF ENERGY'S SAFETY ANALYSIS REPORT  
SECTIONS 1.2.4, 1.2.5, 1.2.8, 1.3.4, 1.4.2, 1.14.2 and 1.14.3)

Reference : Ltr, Jacobs to Williams, dtd 7/10/09, "Yucca Mountain - Request for Additional Information - Volume 2, Chapter 2.1.1.2, Set 1 (Department of Energy's: Safety Analysis Report Sections 1.2.4, 1.2.5, 1.2.8, 1.3.4, 1.4.2, 1.14.2 and 1.14.3)"

The purpose of this letter is to transmit the U.S. Department of Energy's (DOE) supplemental response to Request for Additional Information (RAI) number 14, provided by the Nuclear Regulatory Commission in the above-referenced letter. The original DOE response to RAI number 14, Volume 2, Chapter 2.1.1.2, Set 1 was provided on August 26, 2009.

There are no commitments in the enclosed RAI supplemental response. If you have any questions regarding this letter, please contact me at (202) 586-9620, or by email to jeff.williams@rw.doe.gov.

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OTM: SAB-0116

Enclosure:

Supplemental Response to Request for Additional Information  
Volume 2, Chapter 2.1.1.2, Set 1, Number 14



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**RAI Volume 2, Chapter 2.1.1.2, First Set, Number 14, Supplemental Question 10:**

Provide a description of the design methodology and design codes and standards that will be applied to ensure that the synchronous optical network ring capacity and integrity will be adequate, including margin, to accommodate a) the volume of wireless transmissions of real-time video from video cameras on subsurface mechanical handling equipment (e.g., the transport and emplacement vehicle (TEV) and the remotely operated vehicle (ROV)), b) the simultaneous volume of information from other equipment (e.g., wireless routers, coaxial cable radiating antennas), c) a methodology for mitigation of signal losses (including multipath) for the 2.4 GHz carrier system, and d) the implementation of security features for wired and wireless communication subsystems.

**1. SUPPLEMENTAL RESPONSE**

The communications system for the subsurface facilities contains a wireless interconnection with the synchronous optical network backbone, enabling communications between the Central Control Center Facility (CCCF) and the TEV. The design of the repository synchronous optical network will be in accordance with Alliance for Telecommunications Industry Solutions T1.105-2001, *Synchronous Optical Network (SONET)—Basic Description Including Multiplex Structure, Rates, and Formats*. The synchronous optical network will be implemented with optical carrier level 48. Table 1 of *Synchronous Optical Network (SONET)—Basic Description Including Multiplex Structure, Rates, and Formats* identifies that optical carrier level 48 achieves a transmission line rate of approximately 2,488 Mbps. This transmission line rate provides a capacity equivalent to approximately 1,344 digital signal level 1 lines, providing a sufficient communication bandwidth for the expected demand of 25 Mbps, in response to RAI supplemental question items a) and b) above and discussed in Section 1.2. The response to item “c” is presented in section 1.3, and the response to item (d) is included in the security measures in RAI 2.2.1.1.2-014.

**1.1 SYNCHRONOUS OPTICAL NETWORK CONFIGURATION**

The repository synchronous optical network configuration is shown in SAR Figure 1.4.2-8. The surface facilities are connected via two redundant single mode optical fiber cable rings as the physical transport media for the optical communications backbone, which enables surface-to-surface and surface-to-subsurface communications. The subsurface synchronous optical network configuration also consists of two redundant single mode optical fiber cable rings as the physical transport media for the optical communications backbone. The subsurface synchronous optical network ring originates from the primary node in the CCCF and runs underground through the access main, from the North Portal to the South Portal, then returns above ground to the backup node in Canister Receipt and Closure Facility 1, and finally terminates at the primary node in the CCCF. The node in Canister Receipt and Closure Facility 1 serves as the connection point for the surface and subsurface synchronous optical network rings and as the primary interface point for video and controls between the TEV and the digital control management interface system.

The subsurface synchronous optical network optical nodes are located in each electrical equipment alcove, spaced approximately every 1,750 ft. Each optical node is connected to two

redundant routers that provide wireless communications, via radiating coaxial cable and antennas, to the TEV. The redundant radiating coaxial cables provide wireless communications with the TEV as it travels from the surface facilities and into the access main. Redundant antennas, fed by coaxial cable from the router in the electrical equipment alcove, provide wireless communications with the TEV as it enters the emplacement drift turnout.

## 1.2 WIRELESS DATA THROUGHPUT

The wireless communication links between the redundant routers and the TEV will be allocated to nonoverlapping Channels 1 and 11 to minimize signal interference degradation. The TEV wireless communication system will apply IEEE Std 802.11g/D6.1, *Draft Supplement to Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Further Higher-Speed Physical Layer Extension in the 2.4GHz Band*, which provides payload data rates ranging from 6 Mbps to 54 Mbps, depending on the received signal level.

The TEV will be equipped with five cameras. Each camera will produce a high-resolution video with  $720 \times 480$  pixels per frame at 30 frames per second image resolution, in accordance with the Moving Picture Experts Group-2 (MPEG-2) standards of ISO/IEC 13818-1:2000/Amd.1:2003(E), *Information Technology—Generic Coding of Moving Pictures and Associated Audio Information: Systems, Amendment 1: Carriage of Metadata Over ISO/IEC 13818-1 Streams*; ISO/IEC 13818-2:2000(E), *Information Technology—Generic Coding of Moving Pictures and Associated Audio Information: Video*; and ISO/IEC 13818-3:1998(E), *Information Technology—Generic Coding of Moving Pictures and Associated Audio Information —Part 3: Audio*. The MPEG-2 encoded video is transmitted to both routers located in the electrical equipment alcove to ensure communications are maintained if one of the wireless channels loses connection. MPEG-2 coding rates require an average of 4 Mbps throughput for the high resolution image quality. Therefore, transmitting five high-resolution videos (approximately 20 Mbps) and the TEV control data (approximately 1 Mbps) simultaneously requires approximately 21 Mbps throughput. Adding a 20% overhead (approximately 4 Mbps) to the wireless link requires a total throughput, RAI supplemental question item a) above, of 25 Mbps. The volume of data from the installed subsurface instrumentation, RAI supplemental question item b) above, (e.g., radiation detectors and ventilation monitoring) is less than the volume of video data; therefore, the total throughput is within the IEEE Std 802.11g/D6.1 data throughput capacity of 54 Mbps, and are very much less than the SONET ring capacity of approximately 2488 Mbps.

Several SAR sections refer to ROVs used for inspections and monitoring. These vehicles are used for differing purposes, such as ground support inspection or Performance Confirmation Program activities. Design for the differing ROV concepts presented in the SAR will utilize the same generic communication specifications, including bandwidth limits, as the TEV.

### 1.3 WIRELESS THROUGHPUT BUDGET

Section 19.5.1 of IEEE Std 802.11g/D6.1 states that a received signal level of  $-65$  dBm, as measured at the antenna connector, is required to achieve the 54 Mbps data rate. Therefore, the methodology for radio frequency communications, RAI supplemental question item c) above, with the TEV is to maintain a received signal level of no less than  $-65$  dBm. Mitigation of signal losses is achieved through redundancy of the communications equipment, maximizing transmitter power and the use of high-gain antennas. Figure 1 shows a simplified block diagram of the TEV wireless link and the link budget calculation. The calculated received signal level for the TEV wireless link is approximately  $-64$  dBm. Therefore, the IEEE Std 802.11g/D6.1 wireless link and the synchronous optical network backbone are sufficient for the repository communications system.

### 1.4 WIRELESS COMMUNICATIONS SECURITY

The security measures, RAI supplemental question item d) above, for the wired and wireless communications system are discussed in RAI 2.2.1.1.2-1-014.

### 1.5 EMERGING COMMUNICATIONS TECHNOLOGY

While this RAI response provides a communications system based on proven present-day technologies, alternative emerging transmission options are under review and may be considered as alternative solutions. The specific designation of such technologies and architectures will be conducted during detailed design.

## 2. COMMITMENTS TO NRC

None.

## 3. DESCRIPTION OF PROPOSED LA CHANGE

None.

## 4. REFERENCES

IEEE Std 802.11g/D6.1. 2003. *Draft Supplement to Standard for Information Technology—Telecommunications and Information Exchange Between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Further Higher-Speed Physical Layer Extension in the 2.4GHz Band*. New York, New York: Institute of Electrical and Electronics Engineers. TIC: 254396.

ISO/IEC 13818-1:2000/Amd.1:2003(E). *Information Technology—Generic Coding of Moving Pictures and Associated Audio Information: Systems, Amendment 1: Carriage of Metadata Over ISO/IEC 13818-1 Streams*. Second Edition. Geneva, Switzerland: International Organization for Standardization. TIC: 254395; 255747.

ENCLOSURE 1

Response Tracking Number: 00514-01-00

RAI: 2.2.1.1.2-014

ISO/IEC 13818-2:2000(E). *Information Technology—Generic Coding of Moving Pictures and Associated Audio Information: Video.* Geneva, Switzerland: International Organization for Standardization. TIC: 254947.

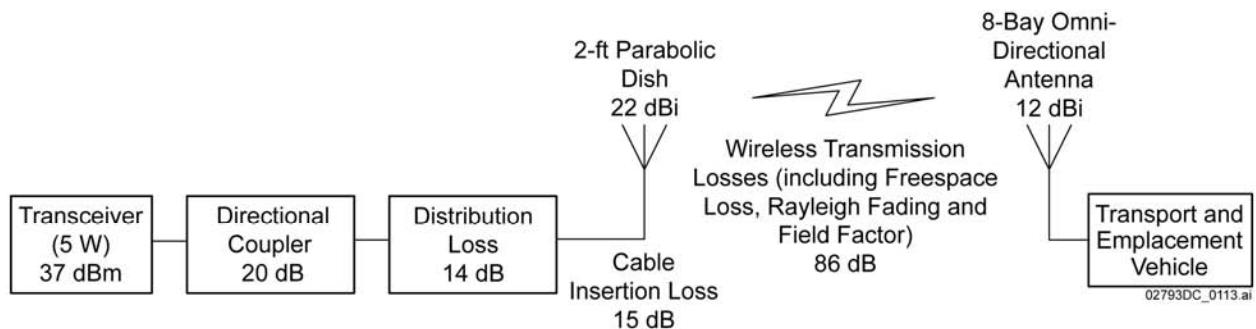
ISO/IEC 13818-3:1998(E). *Information Technology—Generic Coding of Moving Pictures and Associated Audio Information—Part 3: Audio.* Second Edition. Geneva, Switzerland: International Organization for Standardization. TIC: 254950.

T1.105-2001. 2002. *Synchronous Optical Network (SONET)—Basic Description Including Multiplex Structure, Rates, and Formats, Including Supplement T1.105a—2002.* Washington, D.C.: Alliance for Telecommunications Industry Solutions. TIC: 254657.

ENCLOSURE 1

Response Tracking Number: 00514-01-00

RAI: 2.2.1.1.2-014



Received Signal Level = Transmitter Power - Directional Coupler Loss - Distribution Loss - Insertion Loss - Wireless Transmission Losses + Antenna Gains  
Received Signal Level = 37 dBm - 20 dB - 14 dB - 15 dB + 22 dBi - 86 dB + 12 dBi = -64 dBm

Figure 1. TEV Wireless Link Budget Calculation